

of these might be classed as polar outbursts, while the remainder were mostly cold fronts which had traversed the Pacific. In spite of the rather marked outflow of polar air, the individual cold-air masses did not cause any unusual depressions of temperature.

FREE-AIR SUMMARY

By L. T. SAMUELS

Temperature departures for the month were negative at all stations and levels, the greatest departures occurring at Ellendale, the northernmost station. (See Table 1.) The small average lapse rate for the month at this station is a characteristic feature of these higher latitudes during the cold season. It will be seen that the mean temperature was practically no lower at 2,000 meters than at the surface. This small lapse rate becomes even more pronounced and in fact changes to negative to an increasing altitude as the winter advances.

Close agreement is found in the monthly mean temperatures for Broken Arrow, Ellendale, and Groesbeck and the resultant winds at these respective stations. It will be seen in Table 2 that there occurred at the above-mentioned stations either a greater northerly or smaller southerly component than normally. Rather marked exceptions in this respect occur, however, at Royal Center and Due West where despite a deficiency in the monthly mean temperatures the resultant winds contain a greater south component than normally. This anomaly was probably caused by the temperatures at the latter two stations being sufficiently low, on most of the days when the winds were northerly, to offset the relatively high temperatures occurring with southerly winds, even though the latter direction predominated in the resultants.

Relative humidity and vapor pressure departures indicated nothing unusual, the former being mostly positive and the latter negative. (See Table 1.)

Exceptionally strong winds prevailed at various elevations above the surface at a number of stations on the 25th, 26th, and 27th. During this period the center of an extensive low pressure area moved rapidly from Colorado to Quebec. On the morning of the first day Oklahoma City being ideally situated with respect to the low's center the pilot balloon observation showed the characteristic wind structure occurring in the southeast quadrant of a pronounced cyclone, viz, a rapid and marked increase in wind velocity off the surface to 600 meters (7 to 24 m. p. s.) followed by practically no change to 3,000 meters. The observation ended a few hundred meters higher and indicated a decrease in velocity in this upper stratum. The direction was south at the surface and veered to southwest at 600 meters where it remained to the highest altitude reached.

The far-reaching influence of this storm may be realized from the fact that on the 27th with its center over Quebec the wind at 5,000 meters above Atlanta, Ga., was 42 meters per second from the west-northwest and substantially the same at Due West, S. C., about 100 miles to the east. While such tremendous velocities prevailed at these elevations the winds in the lower layers were only light to moderate.

An unusually marked rise in temperature at an elevation of 2,500 meters, while during the same interval a much smaller increase occurred at the surface, is shown by the Broken Arrow kite records for November 21 and 22.

It will be seen from the above table that at the 2,500 meters level the temperature was 8.8° C. higher on the 22d than on the 21st. The increase in surface temperature during this time was only 4.5° C. On the morning

of the 21st this station was in the southeast quadrant of a strong anticyclone whose major axis lay in a northwest-southeast direction and low temperatures and northerly winds prevailed. During the following 24 hours an unusually large and rapid movement of the upper (northern) portion of this HIGH took place, while the lower (southern) portion remained practically stationary, so that the major axis took an east-northeast west-southwest direction with Broken Arrow in the southwest quadrant. Warm southerly winds now raised the temperature in the upper strata to the extent shown above, while the effects of nocturnal radiation prevented such a large increase in the lower air until a considerably later hour in the day. It is of interest to note that exceptionally strong westerly winds prevailed from 1 to 3 kilometers over the northern Plains States, upper Mississippi and Ohio River Valleys coincidentally with the rapid movement eastward of the northern portion of this anticyclone.

Altitude (m.) m. s. l.	21st (8 to 9 a. m.)		22d (7.30 to 10.30 a. m.)	
	Temperature	Wind direction	Temperature	Wind direction
233 (surface)	-3.5	N	-4.8	SW.
500	-6.2	N	-4.2	SSW.
1,000	-7.5	N	-2.6	SW.
1,500	-4.5	NNE	1.0	SW.
2,000	-1.6	NNE	1.5	SW.
2,500	-3.1	NW	5.7	W.
3,000	-4.1	WNW	2.9	WNW.

TABLE 1.—Free-air temperatures, relative humidities, and vapor pressures during November, 1926

Altitude, (m.)	TEMPERATURE (° C.)									
	Broken Arrow, Okla. (233 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (141 meters)		Royal Center, Ind. (225 meters)	
	Mean	De- parture from 9-year mean	Mean	De- parture from 9-year mean	Mean	De- parture from 9-year mean	Mean	De- parture from 9-year mean	Mean	De- parture from 9-year mean
Surface	6.8	-2.7	9.1	-1.6	-5.3	-3.1	11.6	-1.2	2.3	-2.1
250	6.7	-2.7	8.9	-1.6	-----	-----	11.3	-1.3	2.1	-2.1
500	5.3	-3.2	7.7	-1.8	-5.6	-3.4	10.6	-1.4	0.9	-1.9
750	4.3	-3.4	7.1	-1.5	-6.4	-4.3	10.0	-1.4	0.2	-1.8
1,000	4.0	-3.2	6.0	-1.7	-5.7	-3.8	9.4	-1.5	-0.3	-1.7
1,250	3.9	-2.8	5.4	-1.7	-5.0	-3.1	8.8	-1.4	-0.9	-1.7
1,500	3.8	-2.2	4.2	-2.1	-4.6	-2.5	7.9	-1.5	-1.4	-1.6
2,000	2.8	-1.4	2.3	-2.4	-5.4	-1.9	5.7	-1.8	-3.4	-1.8
2,500	1.0	-1.0	0.9	-2.1	-6.8	-1.2	3.8	-1.7	-5.2	-1.8
3,000	-1.4	-1.0	0.0	-0.8	-9.7	-1.5	2.2	-0.9	-7.8	-2.1
3,500	-4.8	-1.9	-3.0	-1.1	-12.6	-1.6	-1.1	-1.4	-9.0	-1.3
4,000	-8.1	-2.7	-----	-----	-15.9	-2.0	-3.4	-1.0	-11.8	-1.1
4,500	-11.3	-3.3	-----	-----	-19.3	-2.5	-5.6	-0.3	-14.2	-0.8

Altitude, (m.)	RELATIVE HUMIDITY (%)									
	Broken Arrow, Okla. (233 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (141 meters)		Royal Center, Ind. (225 meters)	
	Mean	De- parture from 9-year mean	Mean	De- parture from 9-year mean	Mean	De- parture from 9-year mean	Mean	De- parture from 9-year mean	Mean	De- parture from 9-year mean
Surface	68	+2	70	+2	83	+4	68	-6	74	+1
250	68	+2	70	+3	-----	-----	66	-6	74	+1
500	66	+4	68	+3	83	+5	64	-3	72	0
750	64	+5	68	+7	81	+8	62	-1	71	+1
1,000	60	+4	70	+10	76	+8	60	+1	68	+2
1,250	54	+1	65	+8	72	+8	55	-1	64	+2
1,500	49	-1	61	+7	69	+8	52	-1	59	+1
2,000	41	-4	55	+8	66	+9	45	-3	56	+3
2,500	35	-7	43	+3	68	+11	37	-5	51	+2
3,000	38	-3	30	-8	69	+12	37	-2	52	+5
3,500	49	+10	30	-8	73	+15	37	-1	47	+2
4,000	61	+26	-----	-----	72	+11	36	+1	50	+6
4,500	61	+29	-----	-----	71	+9	37	+3	56	+12

Altitude, (m.)	VAPOR PRESSURE (mb.)									
	Broken Arrow, Okla. (233 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (141 meters)		Royal Center, Ind. (225 meters)	
	Mean	De- parture from 9-year mean	Mean	De- parture from 9-year mean	Mean	De- parture from 9-year mean	Mean	De- parture from 9-year mean	Mean	De- parture from 9-year mean
Surface	7.15	-0.79	8.79	-0.32	3.48	-0.83	9.78	-1.82	5.48	-0.85
250	7.08	-0.79	8.61	-0.33	-----	-----	9.41	-1.73	4.91	-1.35
500	6.39	-0.73	7.95	+0.04	3.38	-0.85	8.73	-1.28	4.36	-1.24
750	5.77	-0.72	7.79	-0.57	3.13	-0.80	8.11	-0.85	3.99	-1.10
1,000	5.10	-0.85	7.32	-0.67	3.06	-0.58	7.50	-0.58	3.60	-0.95
1,250	4.39	-1.00	6.35	+0.41	3.00	-0.39	6.54	-0.65	3.21	-0.82
1,500	3.71	-1.11	5.40	+0.17	2.95	-0.21	5.62	-0.77	2.79	-0.79
2,000	2.86	-0.96	4.06	+0.17	2.58	-0.10	3.92	-0.97	2.26	-0.62
2,500	2.30	-0.72	2.71	-0.15	2.34	+0.06	2.77	-0.70	1.77	-0.51
3,000	2.02	-0.44	1.70	-0.54	1.86	+0.02	2.81	+0.10	1.39	-0.58
3,500	2.04	+0.18	1.18	-0.63	1.56	+0.01	2.59	+0.48	1.04	-0.57
4,000	1.98	+0.69	-----	-----	1.19	-0.10	2.45	+0.94	0.73	-0.35
4,500	1.90	+0.98	-----	-----	0.85	-0.27	2.37	+1.32	0.65	-0.12

1 Naval air station.

TABLE 2.—Free-air resultant winds (m. p. s.) during November, 1926

Altitude, (m.)	Broken Arrow, Okla. (233 meters)				Due West, S. C. (217 meters)				Ellendale, N. Dak. (444 meters)				Groesbeck, Tex. (141 meters)				Royal Center, Ind. (225 meters)				Washington, D. C. (34 meters)	
	Mean		9-year mean		Mean		6-year mean		Mean		9-year mean		Mean		9-year mean		Mean		9-year mean		Mean	
	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.
Surface.....	S. 43° W.	1.6	S. 42° W.	1.5	S. 42° W.	1.2	N. 51° W.	0.6	N. 17° W.	3.0	N. 50° W.	2.3	S. 62° W.	1.2	N. 72° E.	0.1	S. 37° W.	3.1	S. 47° W.	2.2	N. 61° W.	1.8
250.....	S. 41° W.	1.7	S. 40° W.	1.6	S. 40° W.	1.2	N. 83° W.	0.7					S. 24° W.	2.4	N. 46° W.	0.6	S. 36° W.	3.6	S. 51° W.	2.8	N. 72° W.	3.2
500.....	S. 89° W.	1.6	S. 40° W.	2.3	S. 49° W.	1.9	S. 88° W.	1.3	N. 25° W.	2.8	N. 59° W.	2.6	S. 33° W.	4.5	S. 4° E.	1.6	S. 37° W.	6.6	S. 56° W.	5.4	N. 73° W.	4.9
750.....	S. 49° W.	2.9	S. 42° W.	3.3	S. 51° W.	2.7	W.	1.9	N. 32° W.	4.0	N. 60° W.	4.1	S. 32° W.	5.5	S. 24° W.	2.2	S. 43° W.	8.0	S. 61° W.	6.7	N. 74° W.	5.9
1,000.....	S. 70° W.	4.3	S. 55° W.	4.0	S. 55° W.	4.0	S. 85° W.	2.7	N. 37° W.	4.6	N. 64° W.	4.9	S. 53° W.	5.7	S. 44° W.	2.9	S. 54° W.	8.6	S. 69° W.	7.3	N. 75° W.	6.8
1,250.....	S. 80° W.	5.8	S. 64° W.	4.8	S. 70° W.	6.1	W.	4.1	N. 40° W.	5.4	N. 65° W.	5.9	S. 61° W.	5.8	S. 57° W.	3.5	S. 61° W.	7.8	S. 72° W.	7.5		
1,500.....	N. 85° W.	6.9	S. 72° W.	5.5	S. 67° W.	7.0	S. 88° W.	5.4	N. 40° W.	6.8	N. 62° W.	7.0	S. 76° W.	6.4	S. 69° W.	4.1	S. 67° W.	9.0	S. 77° W.	8.7	N. 79° W.	8.5
1,750.....	N. 75° W.	8.1	S. 79° W.	6.9	S. 71° W.	8.5	S. 86° W.	7.5	N. 41° W.	8.2	N. 64° W.	8.7	S. 89° W.	7.0	S. 81° W.	5.4	S. 81° W.	10.1	S. 83° W.	10.0	N. 84° W.	10.7
2,000.....	N. 67° W.	9.5	S. 85° W.	7.6	S. 84° W.	10.7	S. 87° W.	9.1	N. 38° W.	11.1	N. 64° W.	10.9	S. 83° W.	10.0	S. 84° W.	7.2	S. 80° W.	11.6	S. 84° W.	11.7	S. 83° W.	11.4
2,500.....	N. 64° W.	12.0	S. 86° W.	8.7	S. 86° W.	14.5	S. 84° W.	10.5	N. 49° W.	13.6	N. 67° W.	12.8	N. 68° W.	13.0	S. 87° W.	8.8	N. 85° W.	12.6	N. 88° W.	13.0	S. 83° W.	15.1
3,000.....	N. 60° W.	14.4	S. 87° W.	9.4	W.	14.5	S. 85° W.	11.8	N. 63° W.	16.2	N. 66° W.	13.9	S. 68° W.	16.1	S. 75° W.	10.5	S. 87° W.	15.1	N. 85° W.	13.4	S. 78° W.	15.6
3,500.....	W.	12.0	S. 84° W.	10.6					N. 62° W.	15.1	N. 66° W.	13.5	W.	16.0	S. 72° W.	8.6	N. 71° W.	15.9	N. 87° W.	13.0	S. 90° W.	17.6
4,000.....	W.	13.9	N. 84° W.	10.6					N. 74° W.	15.8	N. 62° W.	13.5	W.	17.0	S. 69° W.	10.7	W.	12.0	S. 84° W.	13.0	N. 83° W.	18.4
4,500.....	S. 68° W.	16.0	S. 73° W.	11.9													W.	11.0	W.	15.5	N. 88° W.	21.8

THE WEATHER ELEMENTS

By P. C. DAY, In Charge of Division

PRESSURE AND WINDS

The first week was moderately free from important cyclonic or anticyclonic movements in any part of the country, and this condition continued in the more western districts until the close of the first decade.

By the morning of the 8th, however, a cyclone of slight intensity, that had moved from the far Northwest, reached central Oklahoma and had developed into a well-defined storm. This moved to the Great Lakes and lower St. Lawrence Valley during the following 48 hours, attended by widespread precipitation from the Mississippi Valley eastward, with heavy rains in the Gulf States, Ohio Valley, and North Atlantic States and more or less snow or sleet in the lake region and to eastward.

In connection with this cyclone numerous thunderstorms occurred on the afternoon of the 9th over the southeastern and eastern States, and a small, but severe, tornado occurred at La Plata, Md., causing the death of 17 persons, mostly children, when a schoolhouse was blown to pieces, injuring a number of others, and destroying a number of houses and other property. (See p. 462, this REVIEW.)

At the beginning of the second decade low pressure developed over the North Pacific coast attended by precipitation, which gradually extended over all parts of the coast, and became heavy in northern California and over the coast districts of Oregon and Washington.

With a short return to anticyclonic conditions over this area about the middle of the month, rainy conditions again overspread the far Northwest and continued without material breaks till the end of the month, the precipitation area extending frequently to all parts of the coast States, with local heavy rains at the lower elevations and some heavy snows in the mountains.

In the districts from the Rocky Mountains eastward, an important cyclone moved from the middle Plains to the upper Lakes on the 13th to 15th, and with secondary formations the precipitation area was extended to nearly all eastern districts during the following two days. Heavy rains occurred in connection with this cyclone over the upper Mississippi Valley, portions of the Gulf States, Ohio Valley, and to the northeastward.

Immediately following the storm referred to above, another, having its origin in the far Northwest, crossed the Rocky Mountains about the 16th and moved southeastward to central Texas, and thence to central Arkansas

during the following 24 hours, but without material precipitation. From Arkansas the storm moved northward to the Great Lakes during the following 48 hours, and, as in that just preceding, a secondary low developing to the eastward caused precipitation, mostly light, over practically all central and eastern districts, light snows occurring over the more northern sections.

The latter half of the month was mainly free from cyclonic disturbances from the Rocky Mountains eastward until the 25th, when a cyclone of wide extent, an offshoot from the general low-pressure area in the extreme Northwest, was central over eastern Colorado, and moved rapidly to the Great Lakes and lower St. Lawrence Valley during the 26th and 27th. This storm was attended by thunderstorms over wide areas on these dates, and several distinct tornadoes occurred during the late evening of Thanksgiving day in the lower Mississippi Valley, notably in Arkansas, Louisiana, Mississippi, and Missouri, when a considerable number of lives were lost and much damage to property occurred. A more complete history of these tornadoes appears on p. 466 in this issue. Moderate precipitation from this storm occurred from the Mississippi River eastward, some sleet and glaze in the upper Lake region and more or less snow in all northern districts from the Dakotas eastward.

The last day of the month brought considerable precipitation over the Atlantic coast and middle Gulf States and about the same time over the Pacific coast from north-central California to Washington heavy precipitation occurred. A fall of over 5 inches at Eureka, Calif., on the 29th and 30th established a new record of heavy rainfall for November at that place.

Anticyclones were mainly of only moderate intensity, though that moving southward from Manitoba about the 9th and drifting slowly southeastward during the following few days, caused sharp falls in temperature as it advanced eastward and dominated the weather over the eastern half of the country for several days.

A moderate anticyclone, moving along the northern border from the 26th to 28th, was attended by sharp falls in temperature as it advanced eastward and by the coldest weather of the month over the northern districts from Minnesota to New England.

The average pressure reduced to sea level was highest over the Southeastern States, where it was slightly above normal, and lowest in the far Northwest where it was materially lower than normal. In general, pressure was above normal over the Atlantic and Gulf States, in the far Southwest, and over the upper Missouri Valley and adjacent Provinces of Canada, and below in other areas.